Cost-Utility Analysis of AI-Assisted Ultrasound for Breast Cancer Detection in Taiwan

Yi-Yi Kung[1,2], Ching-Yuan Fang[1,2], Cheng-Shen Chan[3], Rong-Tai Chen[4], Ping-Hsuan Hsieh[1]

1. College of Pharmacy, National Defense Medical University, Taipei, Taiwan, R.O.C.
2. Department of Pharmacy, Tri-Service General Hospital, National Defense Medical University, Taipei, Taiwan, R.O.C
3. Department of Pharmacy, Tri-Service General Hospital Songshan, Taipei, Taiwan, R.O.C
4. TaiHao Medical Inc., Taipei, Taiwan, R.O.C

Background and Aims

- In Taiwan, 15,259 new cases of breast cancer were diagnosed in 2020, and the age-standardized incidence was **1.7 times higher** than the global average.
- **Mammography** is the primary screening tool, but its sensitivity is limited in women with dense breasts, where **ultrasound** is often used as an adjunct.
- With the advancement of artificial intelligence**, AI-assisted ultrasound (AI-US) systems** have been developed to **enhance** breast cancer detection **accuracy.** The model used in this study demonstrated a sensitivity of 86.56% and a specificity of 63.75%.
- Using the BI-RADS system for standardized classification, this study aimed to evaluate **whether** AI-US represents a **cost-effective** alternative to conventional ultrasound for breast cancer screening and diagnosis.

Methods

Model Structure and Data

- **Perspective**: National Health Insurance in Taiwan
- **Population**: women ≥30 years, first-time breast ultrasound screening
- **Time horizon**: 40 years; **discount rate**: 3% (costs & QALYs)
- **Model**: decision tree + Markov model (***Figure 1 & 2***)
- **Strategies**: traditional ultrasound (US), AI-US
- **Outcomes**: costs, QALYs, ICERs; health states include diagnosis, missed cancer, stage 0–4, death
- **Willingness-to-pay (WTP) threshold**: 1-3 GDP per capita ($32,000-96,000,TWD 1,010,600-3,031,800)

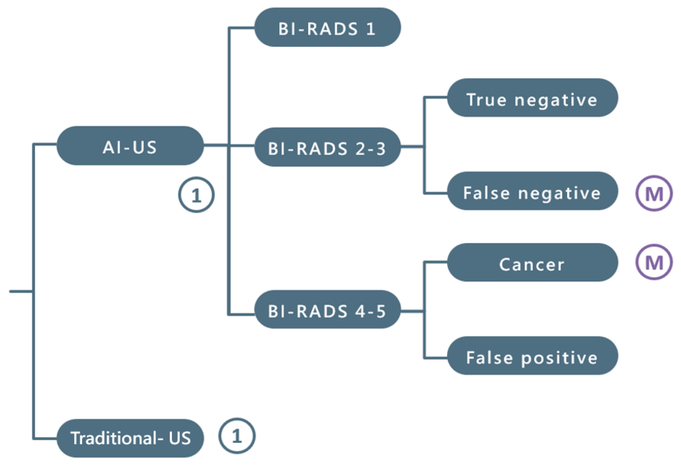

Figure 1. *Decision tree to simulate the diagnostic process of breast cancer patients*

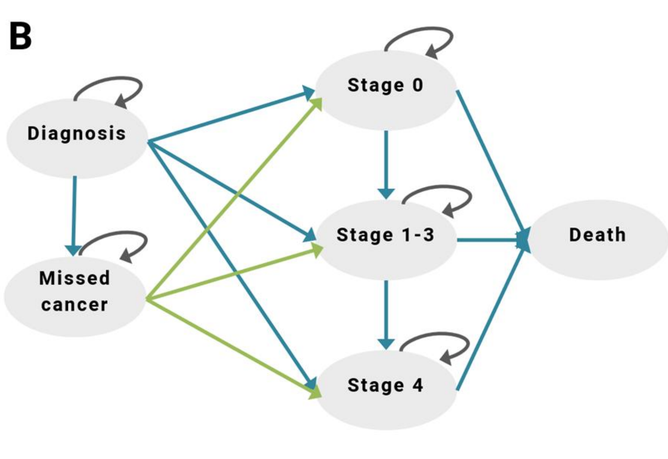

Figure 2. *Markov model to simulate the prognosis of breast cancer patients*

Results

Base-Case Results

- AI-US identified 97 more true positives and 96 fewer false negatives per 10,000 women.
- In **Table1**, AI-US incurred an additional cost of $1,578 with an incremental gain of 0.02 QALYs, resulting in an ICER of $63,146 per QALY gained. Under Taiwan's 1–3 times GDP per capita, AI-US is considered cost-effective compared with traditional ultrasound.

Table 1. *Costs, effectiveness, and incremental cost-effectiveness ratios of AI-US versus traditional-US.*

Strategy	Cost ($)	Incr. Cost ($)	Effect (QALYs)	Incr. Effect (QALYs)	ICER ($)
AI-US	731,927		30.75		
Traditional-US	729,309	1,578	30.72	0.02	63,146

One-way sensitivity analysis

- **Figure 3** revealed that the parameters exerting the greatest influence on the ICER were: (1) the annual treatment costs for stage I breast cancer patients after the first year, (2) the treatment costs for stage IV breast cancer, and (3) the probability of detecting breast cancer at stage I.
- Although variations in these parameters led to fluctuations in the ICER, most results remained within the cost-effectiveness threshold.

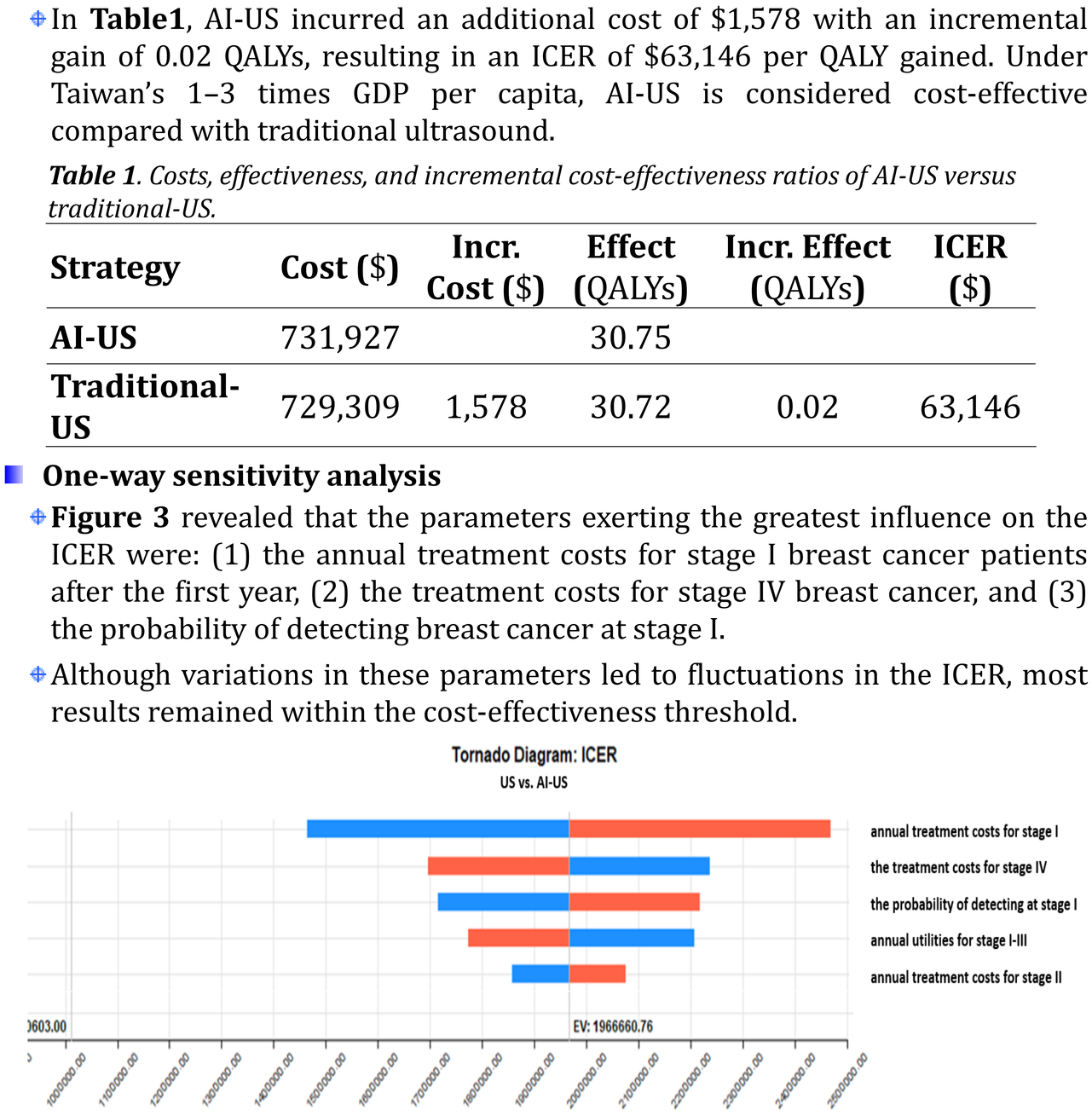

Figure 3. *One-way sensitivity analysis tornado diagram comparing AI-US and traditional-US.*

Probabilistic sensitivity analysis

- The probabilistic sensitivity analysis (5,000 simulations) demonstrated that 49.5% of the iterations fell within the cost-effective region.

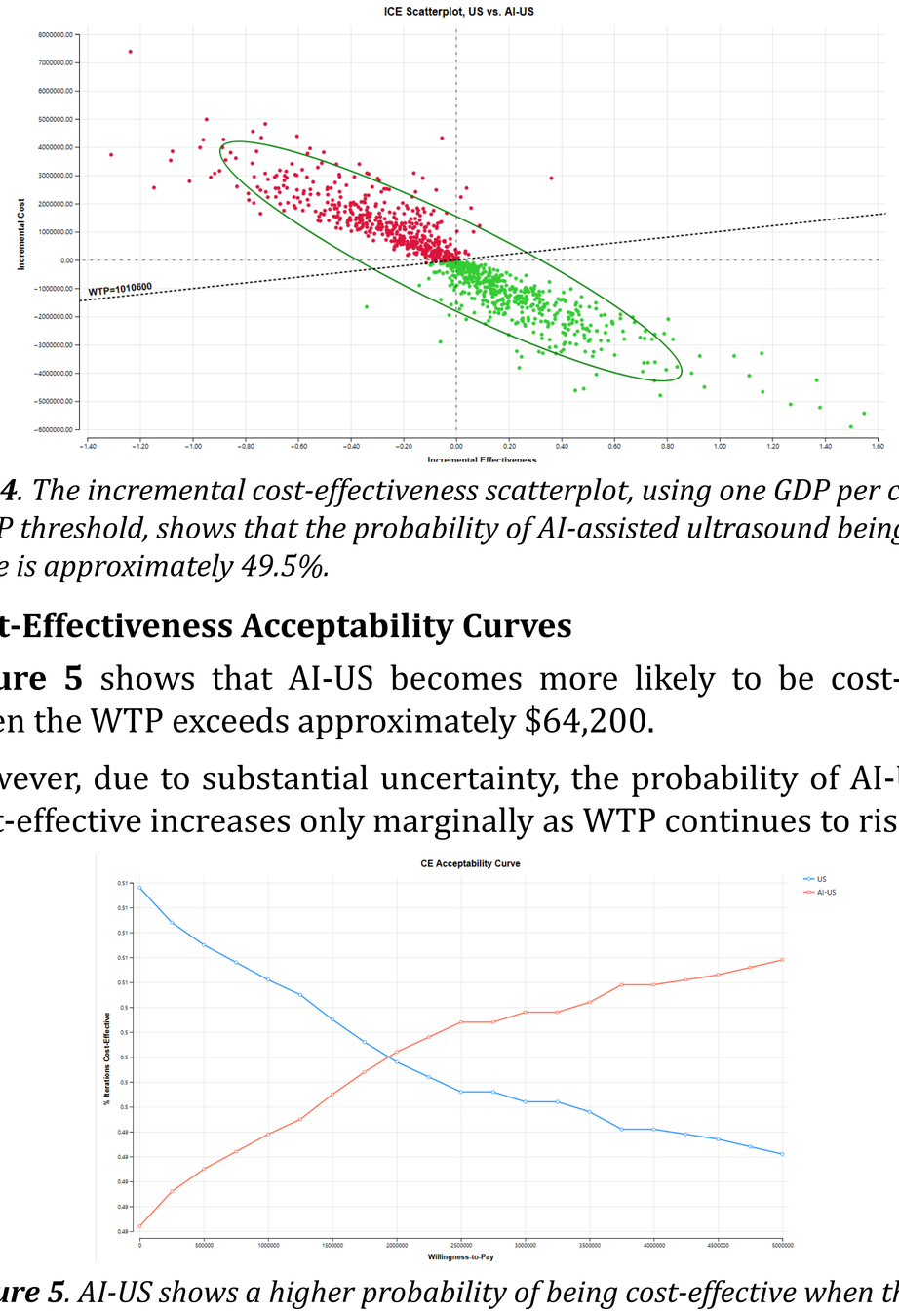

Figure 4. *The incremental cost-effectiveness scatterplot, using one GDP per capita as the WTP threshold, shows that the probability of AI-assisted ultrasound being cost-effective is approximately 49.5%.*

Cost-Effectiveness Acceptability Curves

- **Figure 5** shows that AI-US becomes more likely to be cost-effective when the WTP exceeds approximately $64,200.
- However, due to substantial uncertainty, the probability of AI-US being cost-effective increases only marginally as WTP continues to rise.

Figure 5. *AI-US shows a higher probability of being cost-effective when the WTP exceeds USD 64,200 per QALY.*

Summary of results

- AI-US identified more true positives and fewer false negatives, yielding 0.02 additional QALYs at an incremental cost of $1,535. The ICER was $61,458 per QALY.
- Probabilistic analysis indicated about a 49.5% probability of being cost-effective, with minimal variation across higher WTP levels.

Conclusion

- Although AI-US is likely a cost-effective strategy for early breast cancer detection in outpatient screening among women over 30 in Taiwan, offering improved diagnostic accuracy. However, the considerable uncertainty warrants further investigation.

Reference: 1. Sung, H., et al., Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA: a cancer journal for clinicians, 2021. 71(3): p. 209-249. 2. 台灣衛生福利部國民健康署. Available from: https://www.hpa.gov.tw/Home/Index.aspx. 3. 台灣乳癌篩檢計畫. 4. Mendelson, E.B., et al., Acr bi-rads® ultrasound. ACR BI-RADS® atlas, breast imaging reporting and data system, 2013. 149.

Correspondent to: Yi-Yi Kung Email: yiyi.kung1030@gmail.com